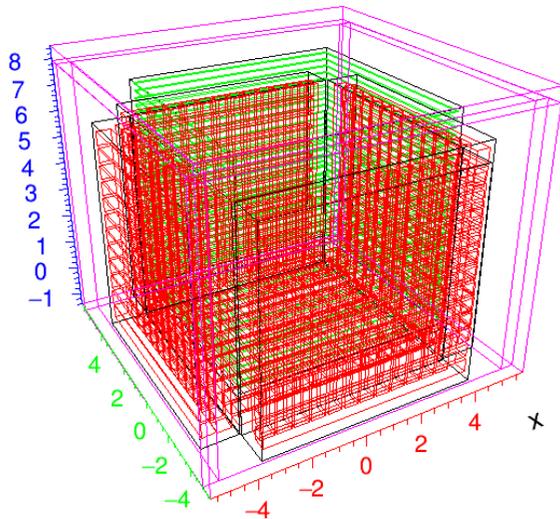

Riccardo Rando
Dept. of Physics and Astronomy “G. Galilei”
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MeVcube

Towards a Network of GRB Detecting Nanosatellites
September 13 - 14, 2018
Budapest, Hungary



MevCube

Structure similar to e-ASTROGAM, AMEGO (Si DSSD, CsI, ...)

Test sensors, readout, validate design (*pathfinder*, at 1/1000 cost)

Evaluate environment in quasi-equatorial LEO (activation, SAA rates, ...)

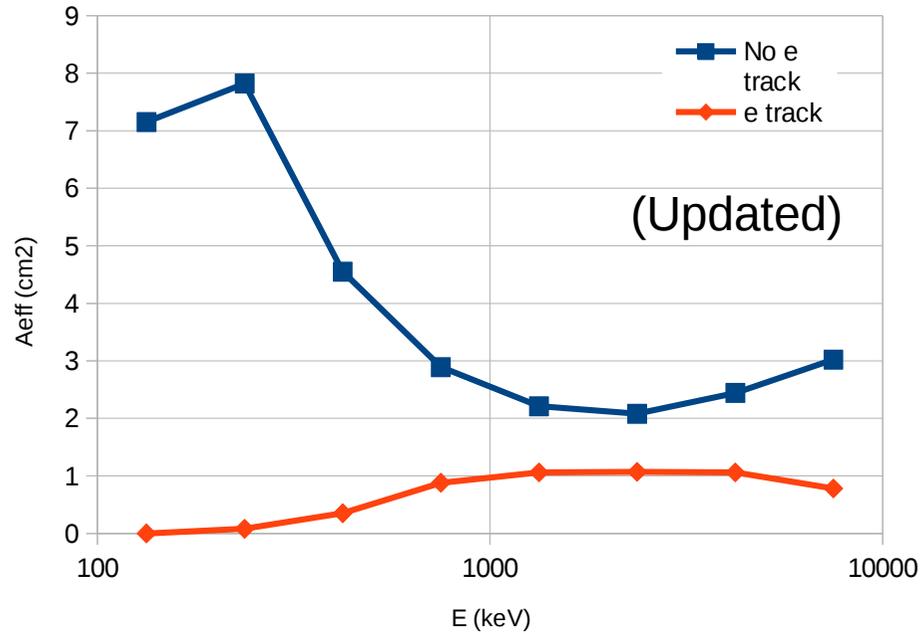
Do science (at least at the COMPTEL level) including GRBs (so *not a dedicated instrument*)

Design is almost fixed, some preliminary performance estimates

Most of the work done by students!

Evaluating mission plan now

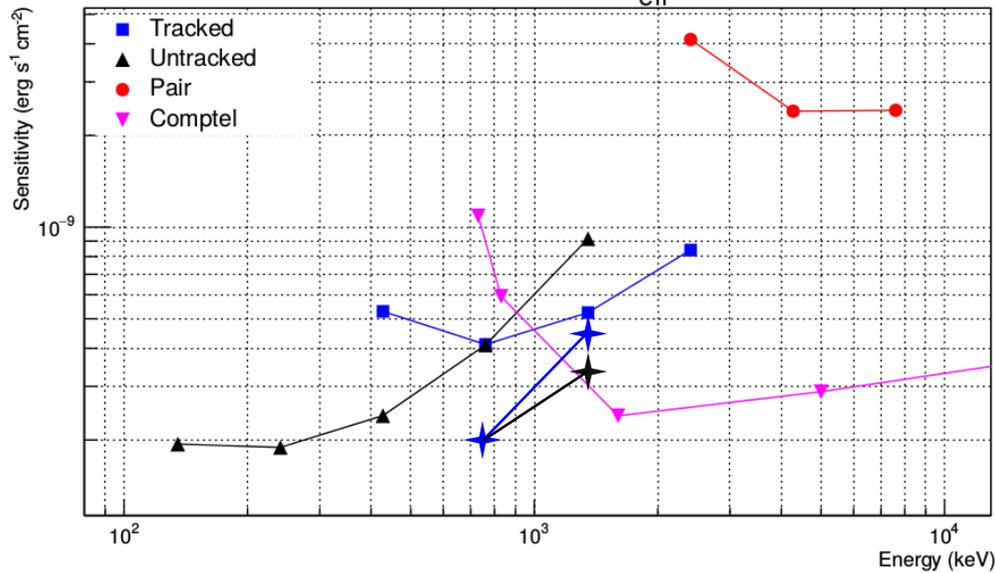
Performance (Berlato, Lucchetta, with updates)



ARM at 1 MeV ~ 5°
 SPD at 1 MeV ~ 30°

(Updated)

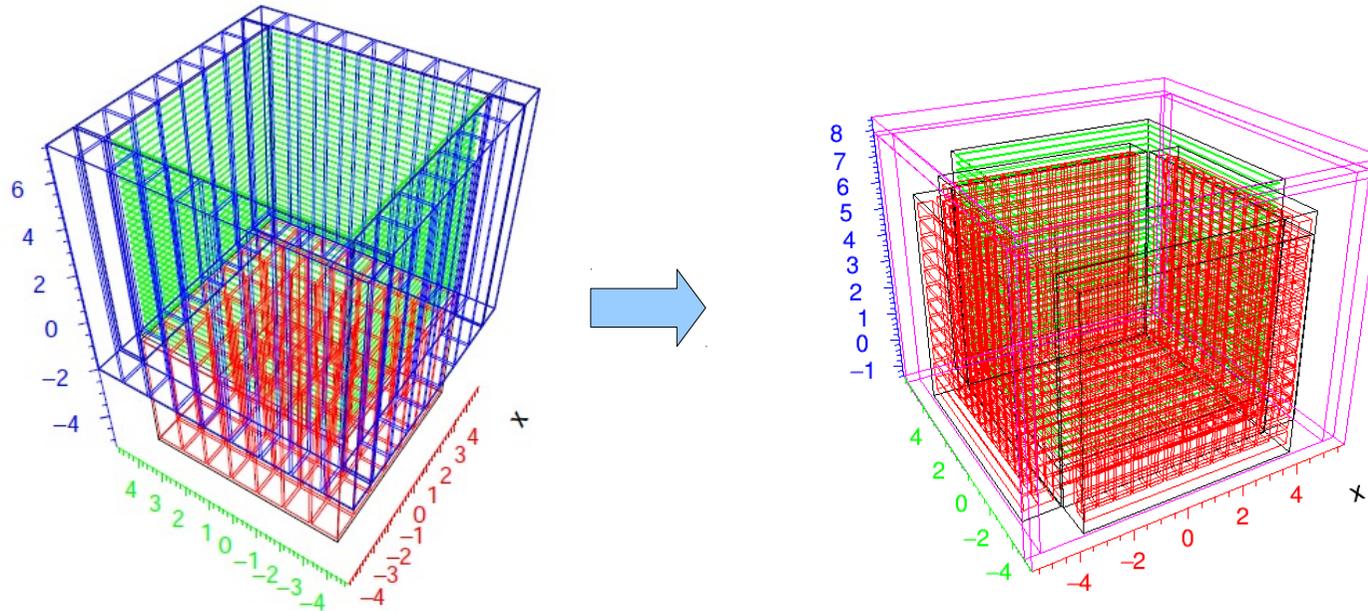
Sensitivity ($z=3\sigma$, $T_{\text{eff}}=10^{\circ}\text{ s}$)



✦ With current design
 PRELIMINARY

(See Lucchetta 2017)

Now finalize



Biggest issue is SNR (5% for a steady source at the sensitivity limit, 10^6 s)
No quality cuts – background rejection cuts yet, since geometry was not fixed
Close a bit FOV and get rid of some of the mess from the Earth limb

Radiation environment (Dal Moro)

Primary protons, main source of activation for quasi-equatorial orbits (5° and less)
 Differences in proton models up to 1 order of magnitude (AP8 vs AP9)
 Conservative estimate

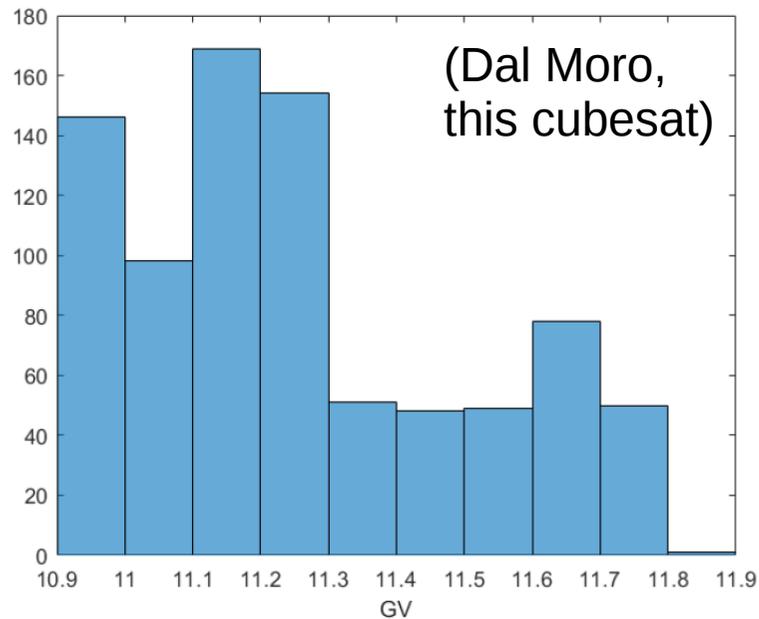
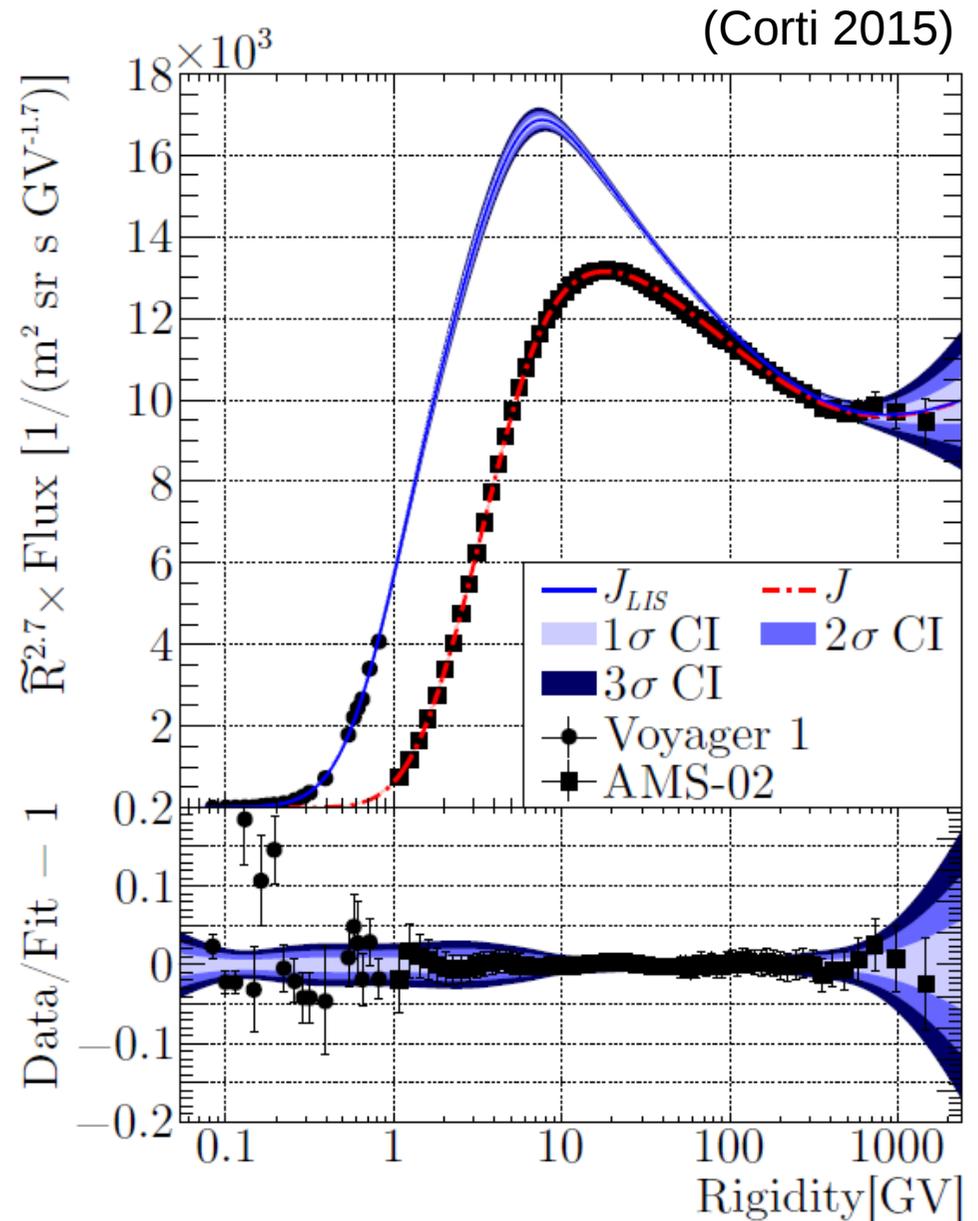
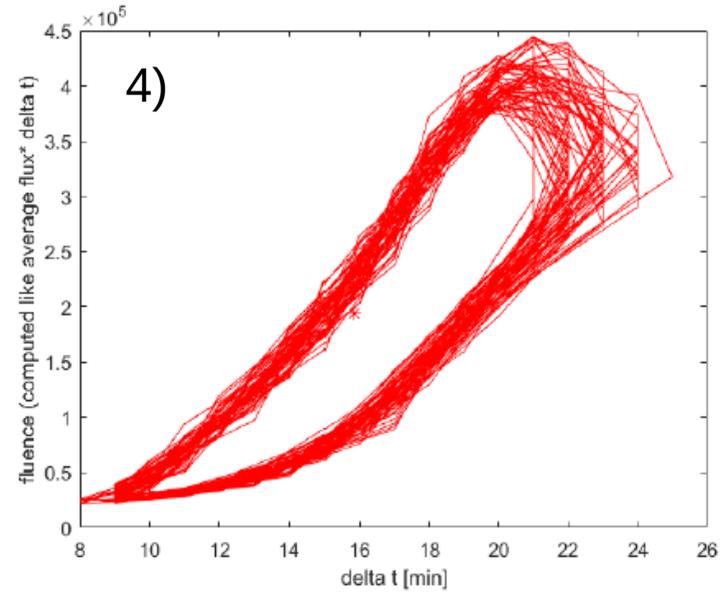
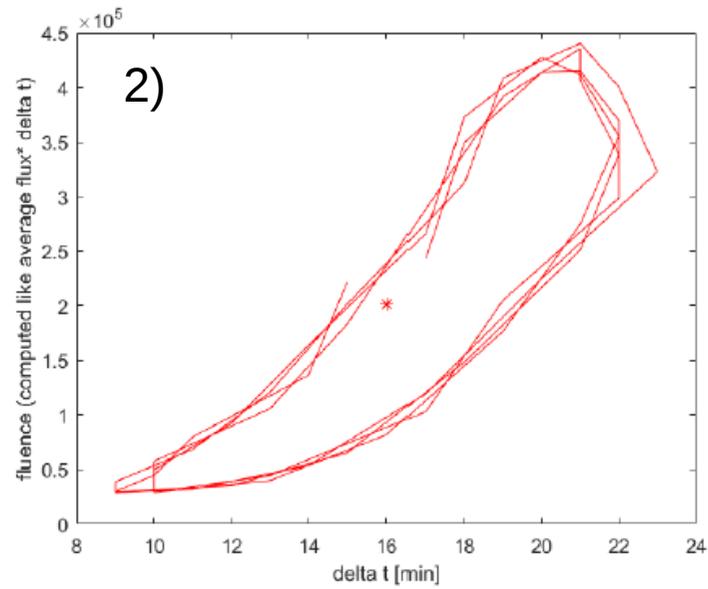
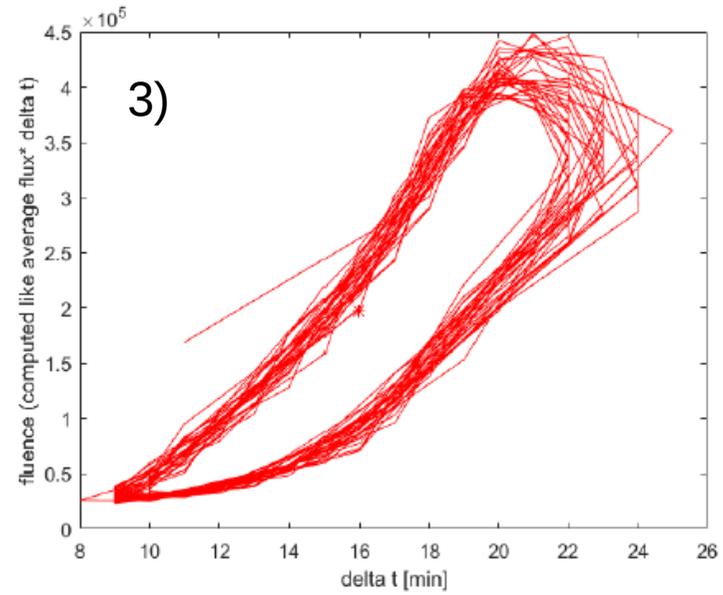
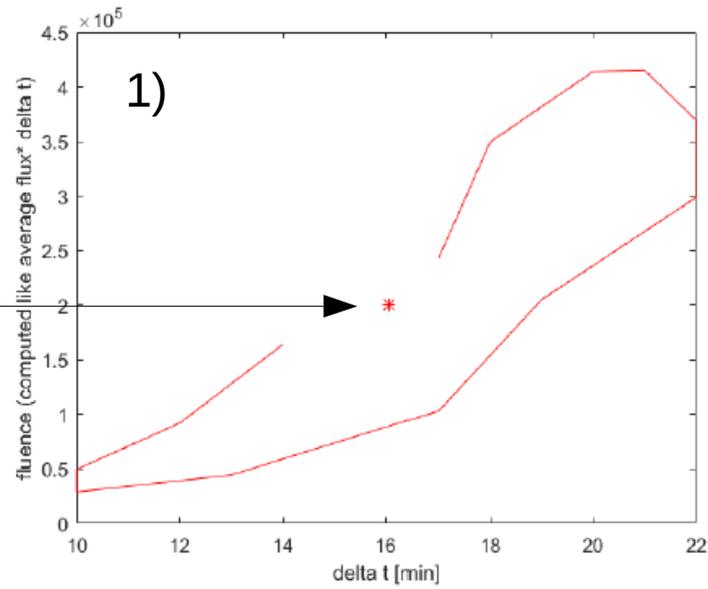


Figure 2.3: Histogram with the distribution level about the vertical cut off

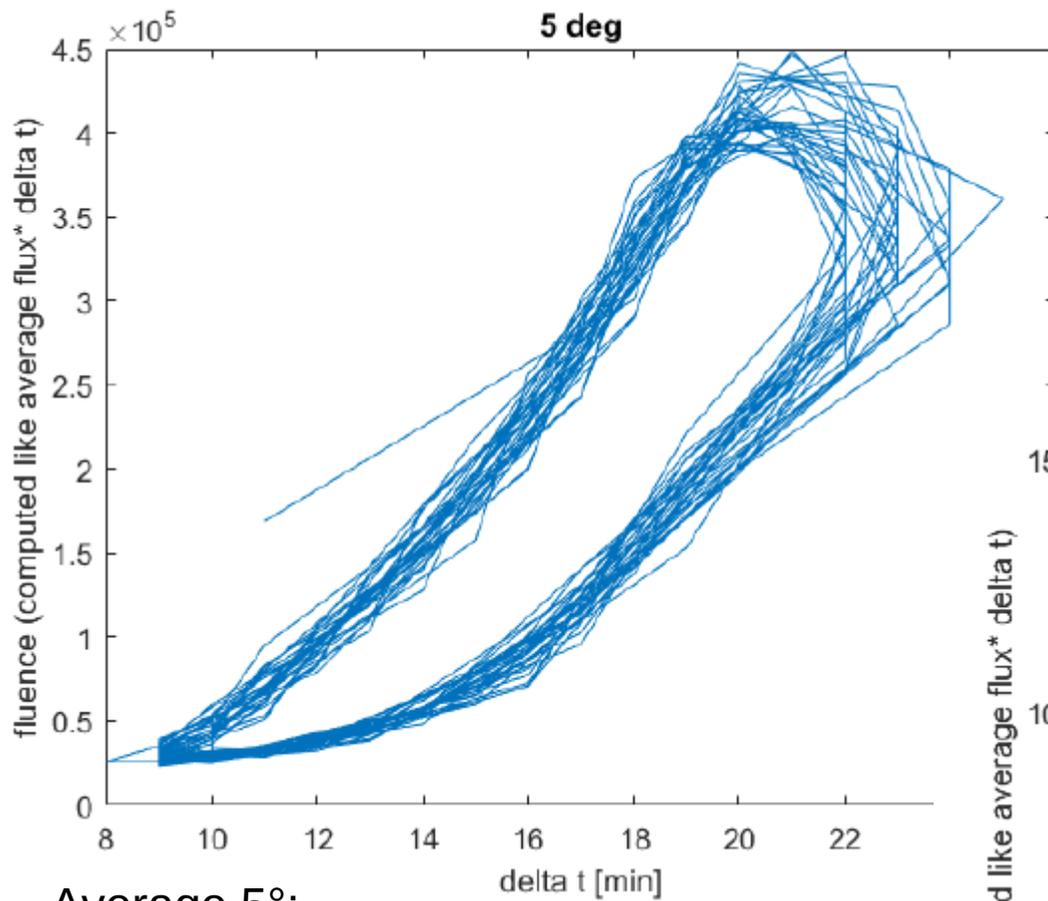


Results: irradiation profiles (trapped)

average

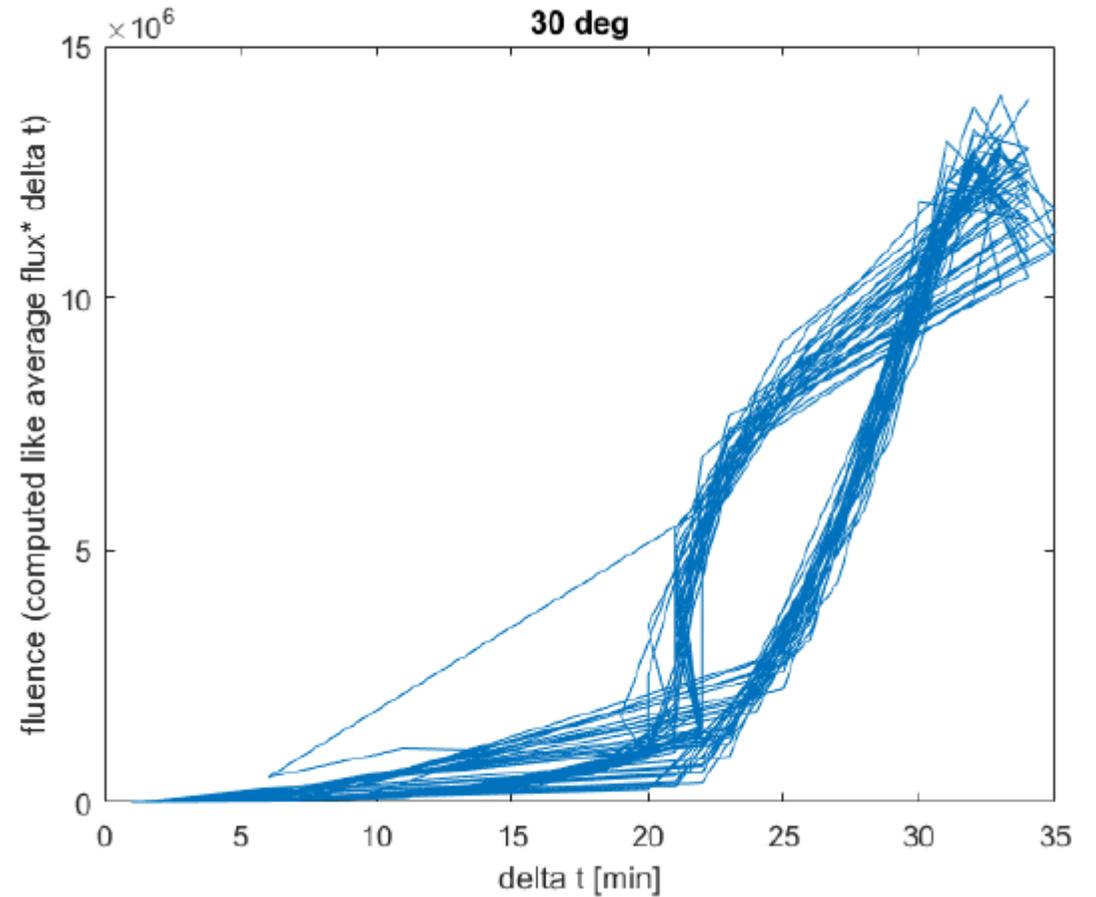


Results: inclination

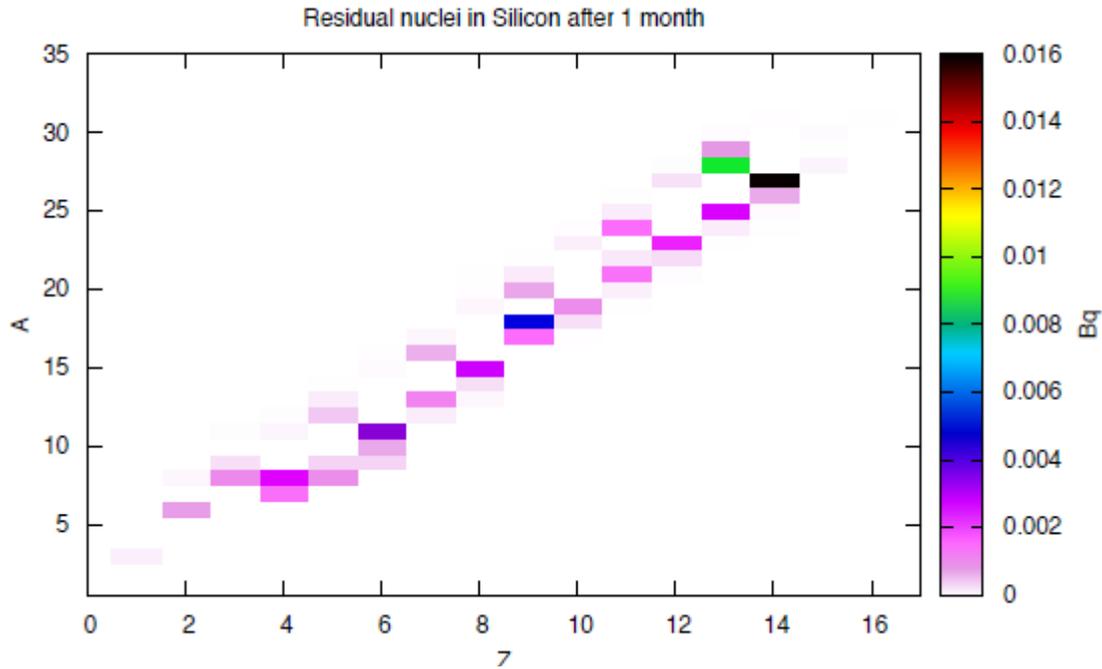


Average 5°:
 $T_{ON} \sim 16$ min
@ 1 MeV $\sim 10^6$ p/cm²/MeV

Average 30°:
 $T_{ON} \sim 20$ min
@ 1 MeV $\sim 5 \cdot 10^6$ p/cm²/MeV
30 deg



Activation (Andreetta)



For now only primary protons (main)
To do: trapped, neutrons, etc.

Isotopes with highest activity in Si

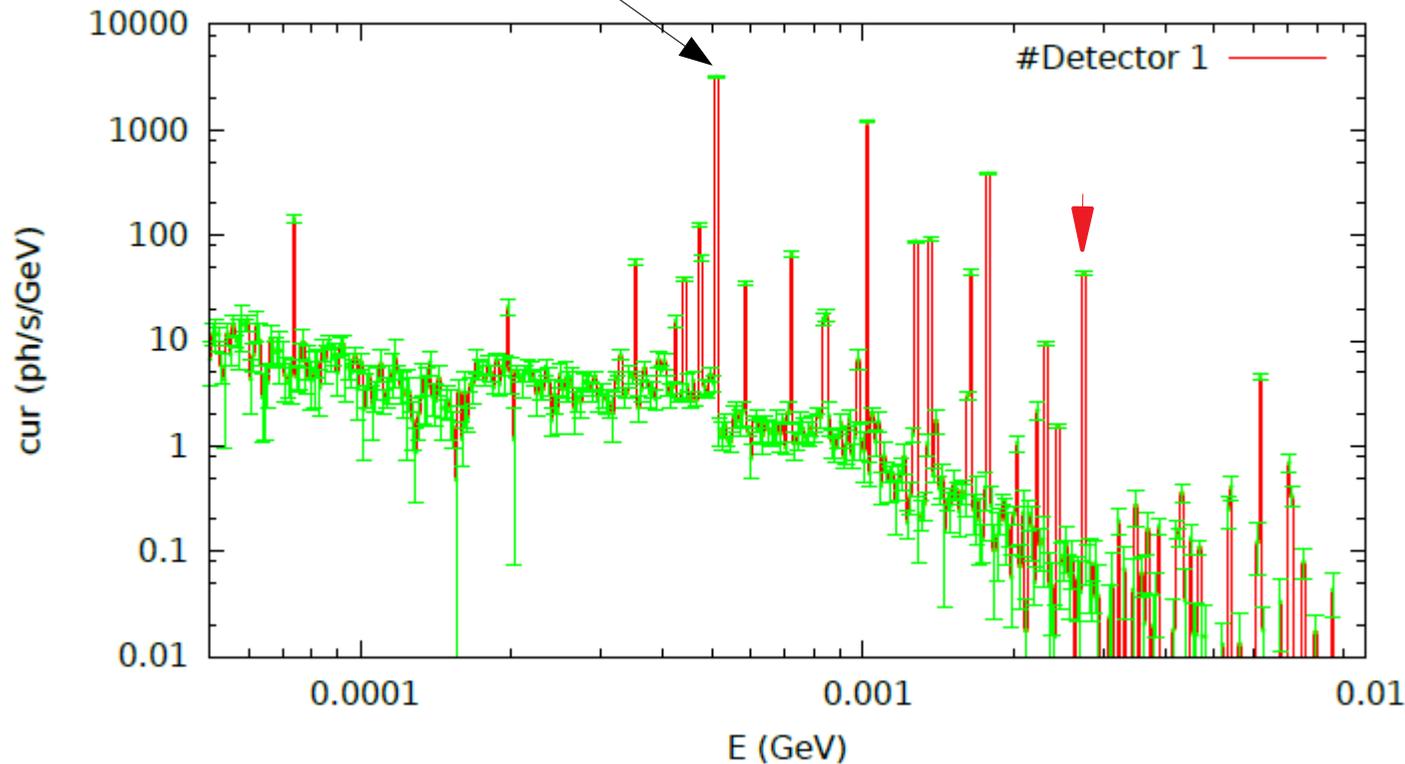
Isotope	Activity [Bq]	$T_{1/2}$ and error	Decay	γ produced [keV]
${}^{20}_9F$	$(6.93 \pm 0.19) \cdot 10^{-4}$	11.00 (2) s	β^-	1633.602
${}^{24}_{11}Na$	$(1.51 \pm 0.02) \cdot 10^{-3}$	14.9590 (12) h	β^-	1368.633; 2754.028
${}^{28}_{13}Al$	$(8.90 \pm 0.03) \cdot 10^{-3}$	2.214 (12) m	β^-	1778.969
${}^{29}_{13}Al$	$(8.04 \pm 0.23) \cdot 10^{-4}$	6.56 (6) m	β^-	1273.367
${}^{24m}_{11}Na$	$(7.47 \pm 0.08) \cdot 10^{-4}$	20.20 (7) ms	IT	472.202

Table 4.3: Residual isotopes in Silicon

Results: gamma lines

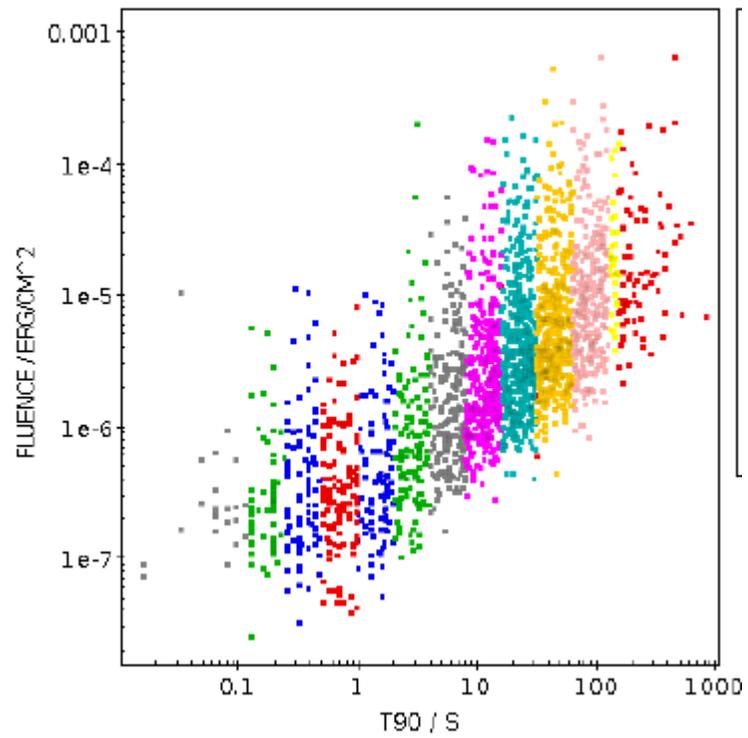
Energy [keV]	Rate [γ/s]	Decay mode	Saturation	Provenience
472.202	$(7.47 \pm 0.08) \cdot 10^{-4}$	IT	yes	$^{24m}_{11}Na$
1273.367	$(7.28 \pm 0.21) \cdot 10^{-4}$	β^-	yes	$^{29}_{13}Al$
1368.633	$(1.51 \pm 0.02) \cdot 10^{-3}$	β^-	yes	$^{24}_{11}Na$
1633.602	$(6.93 \pm 0.19) \cdot 10^{-4}$	β^-	yes	$^{20}_9F$
1778.969	$(8.90 \pm 0.09) \cdot 10^{-3}$	β^-	yes	$^{28}_{13}Al$
2754.028	$(4.45 \pm 0.03) \cdot 10^{-3}$	β^-	yes	$^{24}_{11}Na$

511 keV, from positrons
(mostly β^+ decay)



Worst: ~ 0.1 Bq (CAL)
 511 keV: ~ 1 ph/s
 Simulate as source
 inside the payload
 Triggering eff.: $\sim 10^{-3}$

GRB sensitivity (Canevarolo)



GRB sensitivity (Canevarolo)

The exact formulation of the question affects the results

We opted for the following:

- we will have an alert (it could be internally generated);
- we want to **confirm the alert at 3-sigma significance** (<0.3% chance probability);
- **we want to provide a location of the GRB;**
- the procedure could be automated to **run unassisted**.

Take the *Fermi*-GBM GRB catalog: 1405 GRBs in 6 years

Divide the sample by time duration, simulate 2 representative GRBs per band (**average**, **hard**)

Semi-analytical estimate of flux to have 3-sigma sensitivity

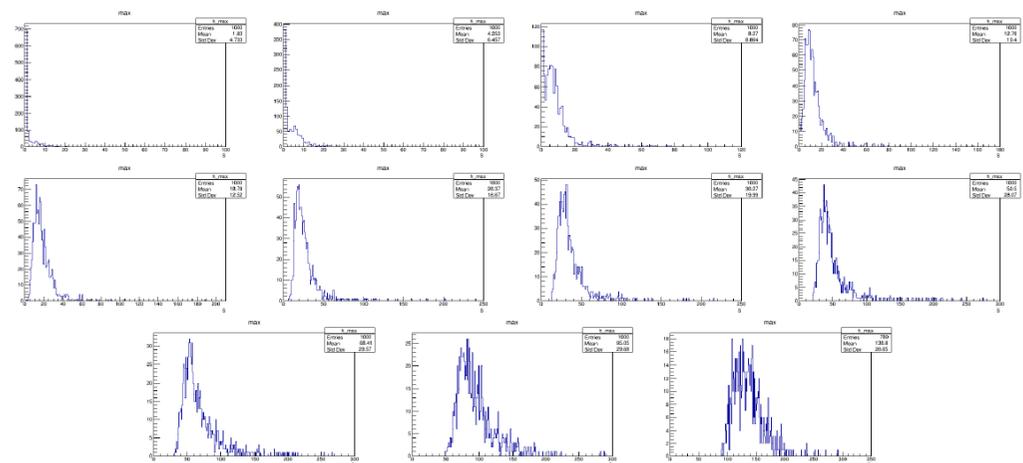
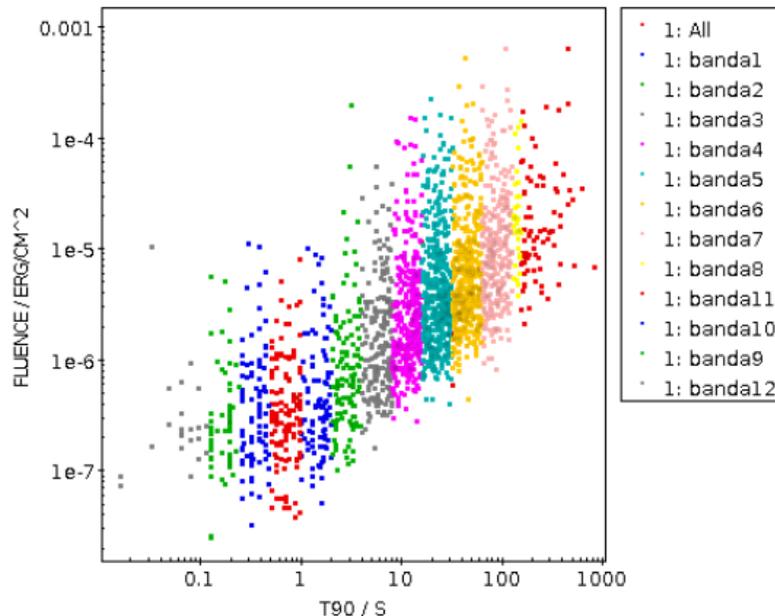
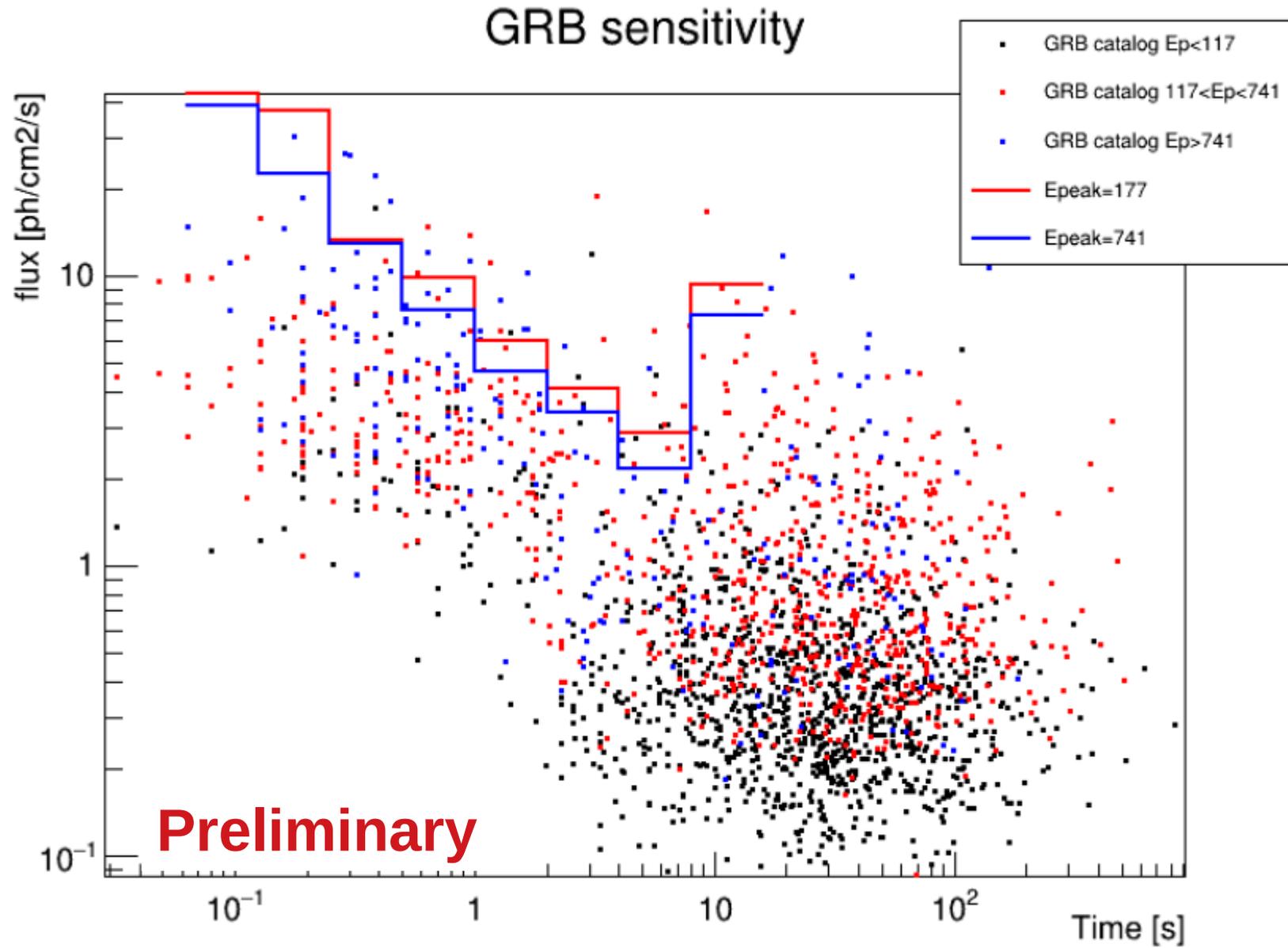


Figure 2.4: Histograms of maximum significance distribution ordered for increasing time band.

Simulated gamma background (1000 realizations each band)

Preliminary results



~7 short GRBs per year (comparable with COMPTEL)
first unassisted localization: $\sigma \sim 10^\circ$

Future activities

Evaluate quality cuts, define response (sensitivity, SNR, FOV, ...)

Evaluate mission plan (launch, orbit, ...) - preliminary plan developed as a student project at UF (course EAS 4700 – AEROSPACE DESIGN 1)

Submitted proposal to Italian ministry (PRIN2017) for an active-pixel MeV payload (adapting an INFN patented technology), fallback to this design if R&D is not satisfactory

The End